Image Relational Search Engine

David Paglieroni
(925) 423-9295
paglieroni1@llnl.gov

Information science is concerned with extracting knowledge from raw data sources. In surveillance and site monitoring applications, data from *in situ* radiation, biological, chemical or motion sensor networks can be used to construct dynamic measurement fields from which anomalies can be detected. Passive and active remote sensing systems are now capable of producing still image coverage over broad area landmasses, and video for persistent surveillance of designated sites.

One overarching goal of information science is to develop a multi-step process for transforming raw data into knowledge. Unformatted raw data must first be transformed into formatted tables or semantic graphs containing items of interest extracted from the data. Patterns of interest must then be extracted from these tables or graphs, or naturally occurring patterns must be discovered. By creating statistical models for dynamic activities of interest, whose components are tied to such patterns, one can evaluate a set of observed patterns against the hypothesis that a particular activity of interest is occurring or is about to occur. Alternatively, one can discover correlations between patterns in historical data so that anomalies can be detected and predictions can be made from incoming data.

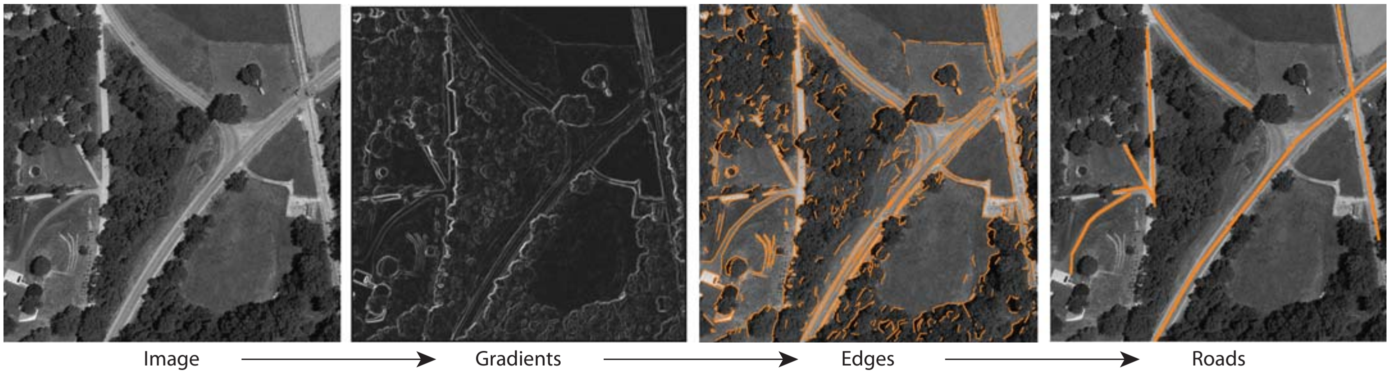

Figure 1. Example of road extraction.

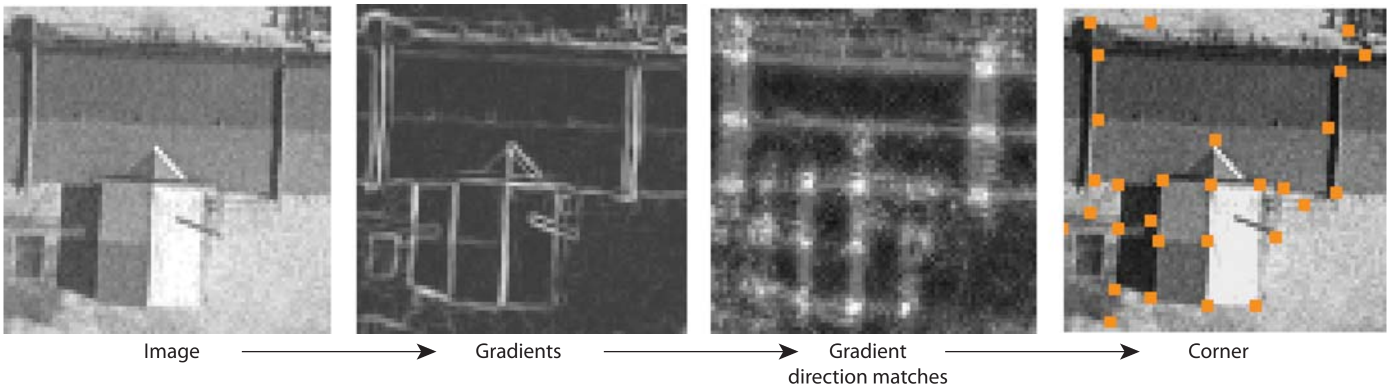

Figure 2. Example of corner extraction.

The Image Relational Search Engine (IRSE) Project focuses on specific aspects of the overall problem described. It addresses only one voluminous raw data source—imagery from remote sensors. The focus of IRSE is limited to extracting items of interest such as roads, buildings, and vehicles from images, and then searching for patterns that contain combinations of items that relate to each other in a prescribed way.

Project Goals

The goals of the IRSE project are: 1) develop algorithms that advance the state of the art in extracting roads and buildings from images; and 2) develop a customized code layer on top of a commercial search engine code that leverages novel algorithms for finding matches to multi-component Probabilistic Relational Models (PRMs) in databases and graphs. The databases and graphs contain items extracted from images. PRMs constructed by experts specify spatial and temporal relationships between these items precisely or with uncertainty.

Relevance to LLNL Mission

IRSE addresses needs in knowledge extraction from overhead images related to LLNL's mission. IRSE is relevant to national security problems involving broad area image search, and database/graph evolution, query, and prediction.

FY2006 Accomplishments and Results

Our linear consolidation algorithm produces road extraction results from images (Fig.1) that go beyond the state of the art. Gradient Direction Matching algorithms developed for matching 3-D objects to images have been modified to extract corners of buildings (Fig.2). We have developed algorithms that quickly extract buildings from images, independent of position, size and orientation, by finding groups of corners that satisfy rectangular shape constraints (Fig.3).

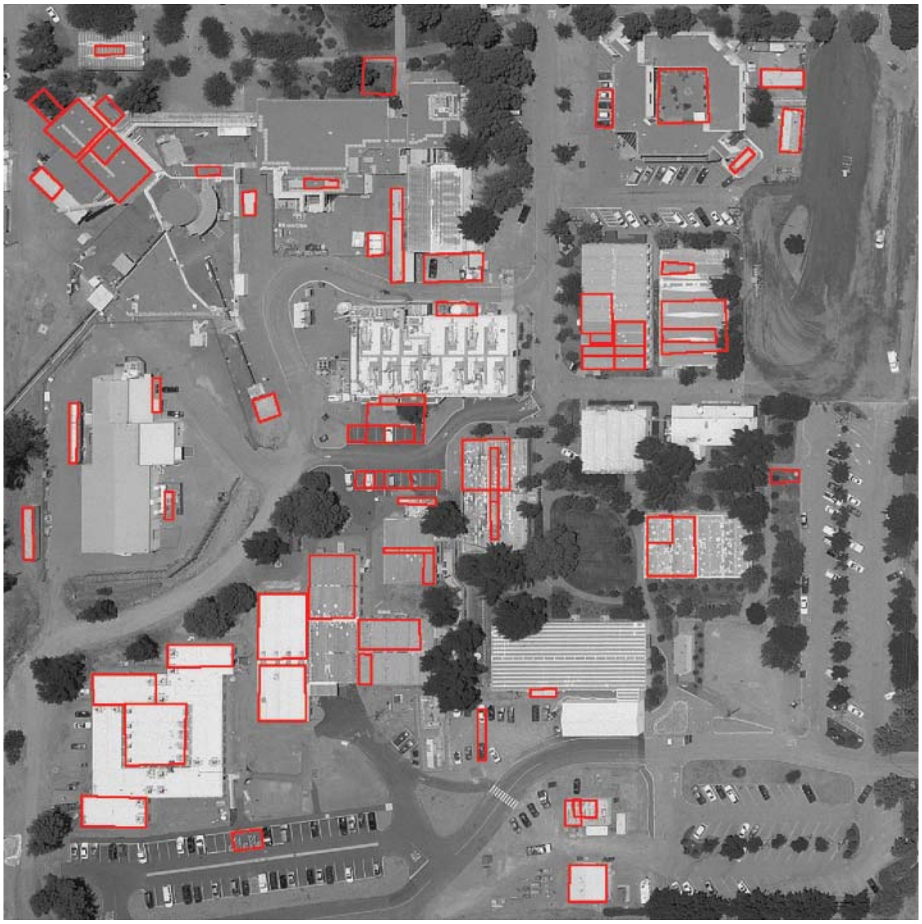

Figure 3. Example of rectangle extraction (dimensions from 25 to 75 pixels).

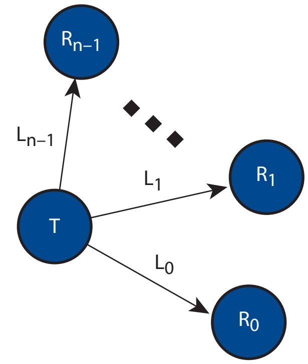

Figure 4. Graphical depiction of Single Transmitter Model with one transmitter item, T, *n* links, L, and *n* receiver items, R.

An algorithm for matching Single Transmitter Models (a type of PRM) to databases and graphs has also been developed (Fig.4). Matching is posed as a minimum cost assignment problem in which candidate items are assigned to model links in an optimal way.

Our method is unique in that it accounts for the following factors simultaneously:

1. the relative significance (importance) of each concept in the pattern model;
2. the similarity between corresponding concepts in the pattern match and the pattern model;
3. the degree of relational consistency between the pattern match and the pattern model;
4. probabilistic uncertainty associated with the pattern model; and
5. links missing from the pattern match.

Related References

1. Chen, B., and D. Paglieroni, "Using Gradients, Alignment and Proximity to Extract Curves and Connect Roads in Overhead Images," *Proc. SPIE D&SS*, pp. 17-21, April 2006.

2. Paglieroni, D., *et al*, "Phase Sensitive Cueing for 3D Objects in Overhead Images," *Proc. SPIE D&SS,* **5809**, pp. 28-30, March 2005.

3. Kuhn, H., "The Hungarian Method for the Assignment Problem," *Naval Research Logistics Quarterly,* **2**, pp. 83-97, 1955.